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CLEAN WATER FOR TODAY:  
What is Wastewater Treatment?

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## **The Clean Water Machine**

How does a wastewater treatment plant work? And, more importantly, why should we care?

This booklet answers those questions by describing the typical publicly owned treatment works (POTW) - or wastewater treatment plant - found in an average town. The first half explains the actual treatment process. The second half addresses other important topics which affect treatment plants.

## **What is the Water Environment Federation?**

The Water Environment Federation, formerly known as the Water Pollution Control Federation, is a not-for-profit educational and technical organization dedicated to enhancing and preserving water quality worldwide. It has been our 40,000 members - water quality specialists from every profession in the field - that have been the driving force behind the United States' clean water programs.

The Federation represents engineers, biologists, managers, chemists, government officials, treatment plant managers, operators, laboratory technicians, students, teachers, and equipment designers and manufacturers. The Federation is composed of 62 Member Associations, three Corresponding Associations, and seven recognized Operator Associations located throughout the world.

## **For More Information**

The following sources were consulted for this publication:

Operation of Wastewater Treatment Plants - Manual of Practice No. 11. WEF, Alexandria, VA. (1976).

Clean Water Act, With Amendments. WEF, Alexandria, VA. (1987).

Glossary - Water and Wastewater Control Engineering. American Public Health Association, American Society of Civil Engineers, American Water Works Association, and WEF, Alexandria, VA. (1981).

Primer For Wastewater Treatment. U.S. EPA, Washington, DC. (1980).

Other WEF public education materials on wastewater include:

"Nature's Way: How Wastewater Treatment Works For You," a colorful brochure which highlights the basics of wastewater treatment.

"Clean Water: A Bargain At Any Cost," a companion brochure which discusses the cost of providing clean water.

"Nature's Way," a ten-minute video which shows viewers how a treatment plant operates.

# Wastewater Treatment: The Cornerstone of Clean Water

The U.S. Congress passed the Federal Water Pollution Control Act Amendments in 1972. While the federal government has been increasingly involved in wastewater treatment since the first comprehensive but weak law enacted in 1948, many state and local efforts go back to the early 1900s. The 1972 statute evolved naturally from two major precursors passed in 1956 and 1965. That statute was one of several environmental protection laws passed in the early 1970's. In each instance, the legislature was responding to a widespread concern that unregulated pollution of America's natural resources would significantly degrade the quality of life in the United States. Interest in water pollution control has remained at a very high level over the intervening period. Public opinion polls continue to show that the electorate appreciates the value of a cleaner environment. What is equally important: they are willing to pay for it, too.

There are many "fronts" in our national campaign to "...restore, and maintain the physical, chemical, and biological integrity of the Nation's waters..." One of the most active but least understood has been the field of wastewater treatment. Since 1972, we have invested over \$50 billion in federal funds plus nearly \$200 billion in matching state and local funds to improve the level of municipal wastewater treatment provided. Wastewater treatment

services are largely taken for granted, however. Few people realize how complex treatment operations are, how useful some of the byproducts can be, or what an amazing bargain this public service has become.

Wastewater treatment facilities appear to be complicated arrangements of machines, pumps, pipelines, tanks and towers. But for all of their complex appearance, treatment plants are designed to do two basic things: speed up the natural purification processes that occur in our streams, rivers, and lakes and reduce toxic contaminants that might otherwise interfere with the natural processes. For over 80 years, professionals in the clean water field have studied these natural processes exhaustively. Treatment technology is altered and refined to reflect new discoveries. Yet the goal of most wastewater treatment operations remains the same: to produce a stream of treated water that is safe for return to the environment.

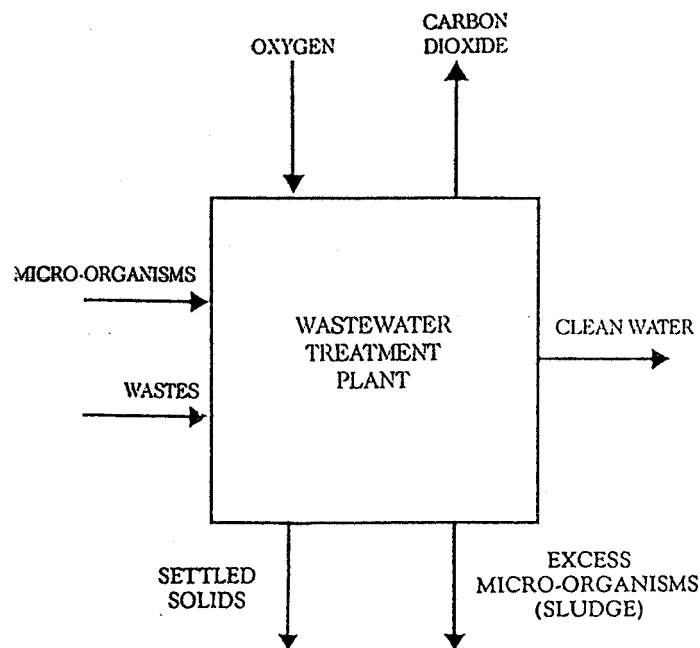
Touring such a facility is a short course in environmental engineering, chemistry, biology, microbiology, and public administration. A treatment plant is a reflection of all our water pollution control efforts. It is the point at which law, science, and politics combine in a direct expression of public policy. The changes in water quality that occur at a treatment plant vividly illustrate what the goal of our Clean Water Act means in real terms.



Much of our leisure time depends on clean water: boating, swimming, fishing, and sunbathing.

# Water Quality and Wastewater Treatment: A Crucial Interaction

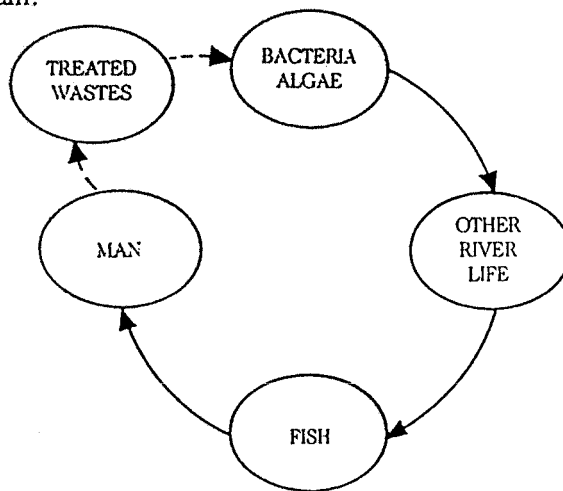
What happens in a wastewater treatment plant is essentially the same as what goes on naturally in a stream or lake. The function of the wastewater treatment plant is to speed up the natural processes by which water purifies itself. In the natural process, bacteria and other small organisms in a stream or lake are attracted to wastewater as a food source. While consuming the food, these organisms produce new bacterial cells, carbon dioxide, and other products. As the wastewater is consumed, the bacteria also consume oxygen. A natural body of water acquires this all-important oxygen by absorbing it from the air and from aquatic plants that use sunlight to turn carbon dioxide present in the water into oxygen (photosynthesis).



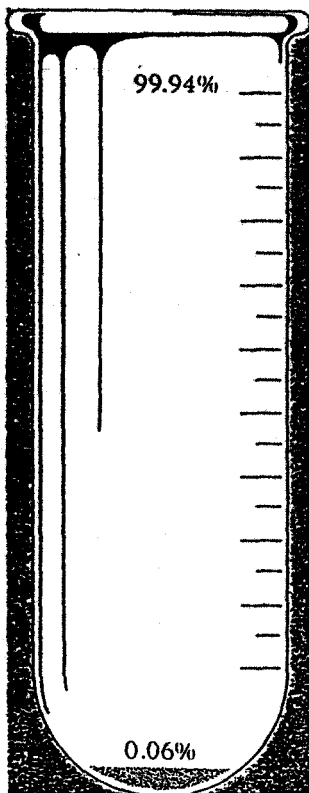
Activities in a wastewater treatment plant closely resemble those which occur naturally in a river or lake.

The life-sustaining characteristics of any body of water depend mainly upon its ability to maintain a certain amount of dissolved oxygen. If only a small amount of wastewater enters a stream, natural bacteria can consume the wastes and fish are not affected; the stream can quickly restore its oxygen loss from the atmosphere and from plants. Trouble begins if the amount of wastewater discharged to the stream is so great that bacteria consuming the wastes rob fish and other beneficial life of oxygen.

Growing population can cause the volume of wastewater to increase beyond the level that the natural process can absorb and purify itself. Wastewater treatment facilities are used as supplements to the natural process. In a wastewater treatment plant, bacteria and other organisms consume the wastes, just as in the natural process, but under more controlled conditions. Once most of the wastes have been oxidized by the bacteria, the treated water can be discharged without harm to the receiving stream.



Biological cycle of a stream shows the interrelation of man, his wastes, and stream life.



Most wastewater is about 99.94% water; only 0.06% is waste.

### What is Wastewater?

Basically, wastewater is the flow of used water from a community. The name is apt, for wastewater is actually 99.94 percent water by weight. The rest, 0.06 percent, is material dissolved or suspended in the water. The suspended material is often referred to as suspended solids to differentiate it from the dissolved contaminants.

Since dissolved oxygen is the key element in the life of a body of water, it is important to measure how much oxygen will be used by bacteria to consume a particular wastewater. The measurement of the required oxygen is called the biochemical oxygen demand (BOD) test. The higher the BOD, the more oxygen will be demanded by the bacteria as they consume the wastes. The removal of BOD is a major goal of wastewater treatment.

Occasionally wastewater may contain substances which cannot be consumed by microorganisms, and therefore, are not part of the BOD. Examples are pesticides, heavy metals, and nutrients. Since these substances may have adverse health or environmental effects in downstream water supplies, it is sometimes necessary to use complex, auxiliary processes to remove what the bacteria cannot consume.

Wastewater contains harmful, disease-causing (pathogenic) bacteria, viruses, and other microorganisms. Accordingly, another important concern in treatment plants is the removal of a large percentage of organisms through disinfection before the wastewater is discharged.

As noted earlier, municipal wastewater is usually 99.94 percent water; thus the concentrations of the constituents discussed are very low. These concentrations are usually discussed as milligrams of pollutant per litre of water (mg/l). One mg/l of a constituent is equivalent to one part of the constituent (by weight) in one million parts of water, or, as expressed in another often-used term, one part per million (ppm). One mg/l or one ppm, to put these terms in perspective, is equivalent to one minute of time in 1.9 years, or one inch in 16 miles. These statistics emphasize that wastewater treatment processes designed to remove a few milligrams per litre of pollutant are similar to sifting a haystack to remove a needle. However, the balance in nature for survival or death of fish depends on the presence or absence of only 2-3 mg/l of oxygen in a stream or lake. A minimum of 4-5 mg/l of oxygen is usually recommended to maintain good fish populations.

# A Typical Treatment Plant: Clean Water Step By Step

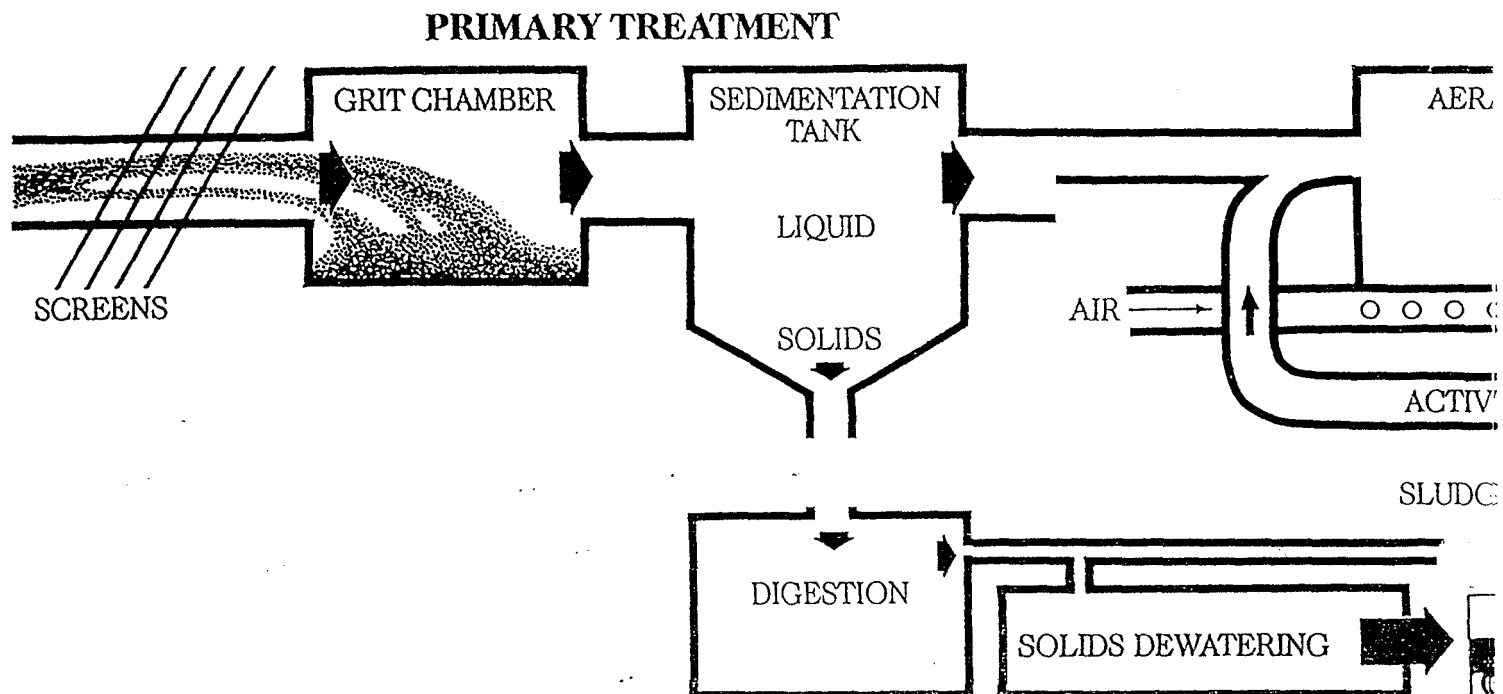
A generally accepted estimate is that each individual, on a national average, contributes approximately 265 to 568 litres of water per day to a community's wastewater flow. While most people think of wastewater as only "sewage", wastewater also comes from other sources—commercial, industrial, and storm and ground water. Generally, each house or business has a pipe or sewer which carry the wastewater to the wastewater treatment plant. Sanitary sewers carry only domestic and industrial wastewater, while combined sewers carry wastewater and storm water runoff. Every reasonable effort is made to exclude storm (inflow) and ground (infiltration) water from the sanitary sewer system. These efforts are usually less successful on older sewer systems that leak.

The wastewater from the sewer system either flows by gravity or is pumped into the treatment plant. Usually, treatment consists of two major steps, primary and secondary, along with a process to dispose of solids removed during the two steps.

In primary treatment, the objective is to physically remove suspended solids from the wastewater either by

screening, settling, or floating. The major goal of secondary treatment is to biologically remove contaminants that are dissolved in wastewater. In secondary treatment, air is supplied to encourage the natural processes of growth of bacteria and other biological organisms to consume most of the waste. These organisms and other solids are then separated from the wastewater. Before discharge to the receiving stream, the water usually passes through a tank where a small amount of chemical (usually chlorine) is added to disinfect the treated water.

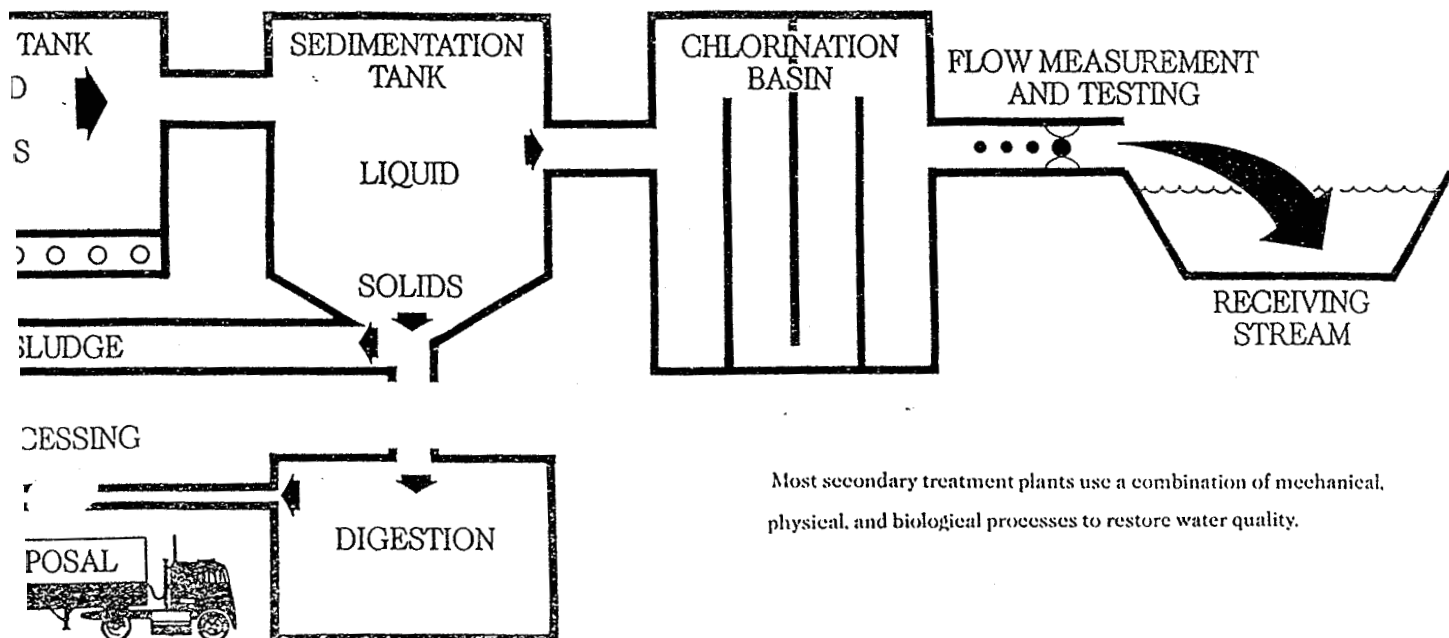
In primary and secondary treatment, solids are settled and removed for further processing. Solids, usually referred to as sludge, are normally processed in three steps—digestion, dewatering and disposal. The digestion step reduces the volatile solids and prepares the sludge for further processing. Dewatering involves the application of a variety of processes that reduces the water content of the sludge and in turn, its volume. The final step is the ultimate management of this treated material, or biosolids, which can be used beneficially through methods such as land application.





We create wastewater when we use water as a way to transport wastes away from our businesses and homes.

## SECONDARY TREATMENT



Most secondary treatment plants use a combination of mechanical, physical, and biological processes to restore water quality.

# Primary Treatment:

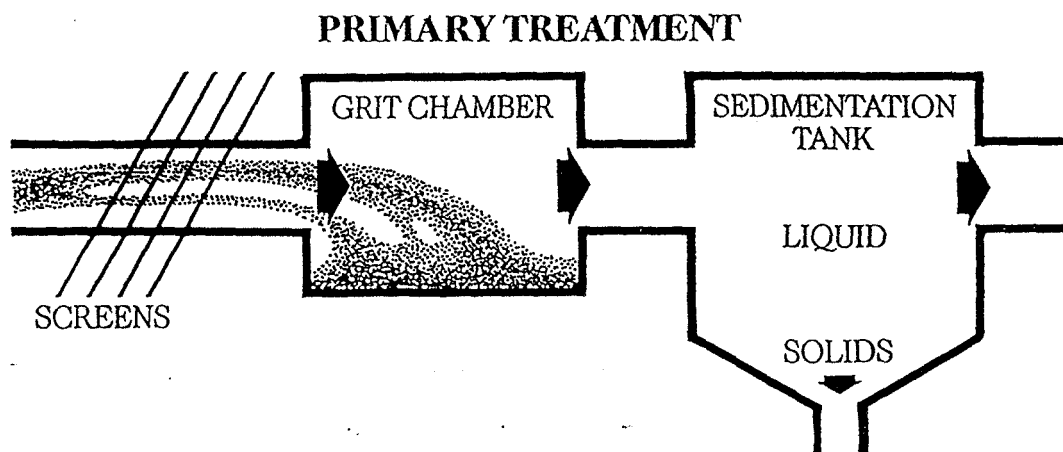
## Physics First

Wastewater entering a treatment plant receives primary treatment first. In this state, a series of operations removes most of the solids that can be screened out, will float, or will settle.

Screening removes large floating objects from the incoming wastewater stream. Treatment plant screens are sturdily built to withstand the flow of untreated wastewater for years at a time. Rags, wood, plastics, and other floating objects could clog pipes and disable treatment plant pumps if not removed at this point. Typically, screens are made of steel or iron bars set in parallel about one-half inch apart. Some treatment plants use a device known as a comminuter which combines the functions of a screen with that of a grinder.

Sand, grit, and gravel flow through the screens to be picked up in the next stage of primary treatment - the grit chamber. Grit chambers are large tanks designed to slow the wastewater down just long enough for the grit to drop to the bottom. Grit is usually washed after its removal from the chamber and buried in a landfill.

After the flow passes out of the grit chamber, it enters a more sophisticated settling basin called a sedimentation tank. Sedimentation removes the solids that are too light to fall out in the grit chamber. Sedimentation tanks are designed to hold wastewater for several hours. During that time the suspended solids drift to the bottom of the tank, where they can be pushed into a large mass by mechanical scrapers and pumped out of the bottom of the tank. The solids removed at this point are called primary sludge. The primary sludge is usually pumped to a sludge digester for further treatment. During the sedimentation process, floatable substances, such as grease and oil, rise to the surface and are removed by a surface skimming system. The skimmed materials are either sent to the sludge digester for treatment along with the primary sludge or are incinerated. Sedimentation marks the end of primary treatment. At this point, most of the solids in the stream than can be removed by the purely physical processes of screening, skimming, and settling have been collected. An additional set of techniques using biological processes must be employed next.

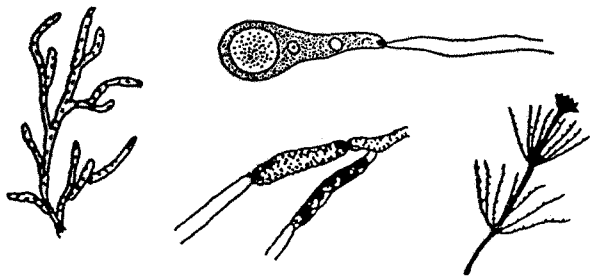


# Secondary Treatment:

## Biology at Work

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Wastewater flowing out of primary treatment still contains some suspended solids and other solids that are dissolved in the water. In a natural stream, such substances are a source of food for protozoa, fungi, algae and hundreds of varieties of bacteria. The secondary treatment stage is a highly controlled artificial environment in which these same microscopic organisms are allowed to work as fast and efficiently as they can. The microorganisms biologically convert the dissolved solids in the wastewater to suspended solids which will physically settle out at the end of secondary treatment.



Many types of microorganisms work together in secondary treatment to consume wastes present in the water.

There are several different ways to optimize biological conversion. Secondary treatment promotes the growth of millions of microorganisms, bringing them into close contact with the wastewater on which they feed. Care is taken to make sure that the temperature, oxygen level, and contact time support rapid and complete consumption of the dissolved wastes. The final products are carbon dioxide, water...and more microorganisms. Three widely employed types of secondary treatment are common: activated sludge, trickling filters, and lagoons.

The most common is the activated sludge process. Activated sludge processes are much more tightly controlled than either trickling filters or lagoons. In this form of treatment, wastewater and microorganisms are mixed for a few hours in a large tank by constant aeration and agitation. Once the aeration is complete, the mixture of water and microorganisms flows to a sedimentation tank similar to the one used in primary treatment. The microorganisms and other solids settle to the bottom of the sedimentation tank. Since activated sludge is a continuous process, a portion of the settled solids (return activated sludge) are circulated back to the beginning of the process to serve as "seed" organisms. The part not needed for "seed" is commonly called waste activated sludge and is sent to a sludge digester for further treatment.

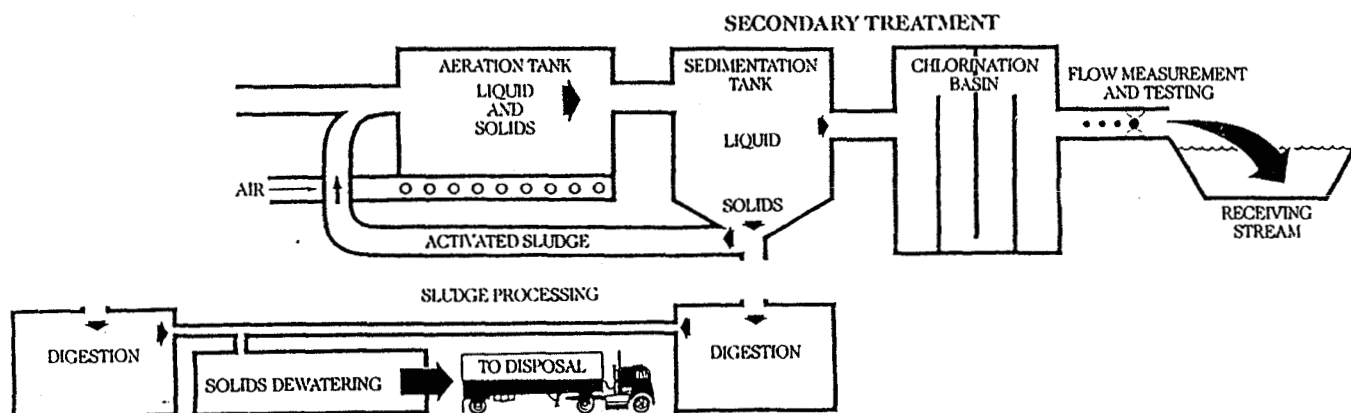
Trickling filters are large beds of coarse, loosely packed material—rocks, wooden slats, or shaped plastic pieces—over which the wastewater is sprayed or spread. The surfaces of the filter material (also known as the “medium”) become breeding grounds for the microorganisms that consume the wastes. A common trickling filter is a bed of stones 3 to 10 feet deep. Under the bed, a system of drains collects the treated wastewater and diverts it to a sedimentation tank or back over the filter medium for additional treatment. In the sedimentation tank, suspended solids settle and are pumped to a sludge digester. Trickling filters are relatively simple to construct and operate. Many communities in the United States rely on them for secondary treatment.

Some communities use lagoons to achieve secondary treatment. Lagoons generally treat the total wastewater from a community until the biological oxidation processes have consumed and converted most of the wastes present. This form of treatment depends heavily on the interaction of sunlight, algae, and oxygen. Sometimes the wastewater

is aerated to speed the process, since these interactions are relatively slow. There is usually no sedimentation tank associated with a lagoon. Suspended solids settle to the bottom of the lagoon where they remain or are removed every few years. Generally speaking, lagoons are simpler to operate than other forms of secondary treatment, but are less efficient.

At the end of a secondary treatment process, the wastewater is disinfected to remove disease-causing organisms. Usually, an agent such as chlorine is added to the stream of wastewater before it is discharged to receiving waters. Sometimes other techniques are used if the receiving waters are sensitive to the addition of chlorine.

An alternate to secondary and higher levels of treatment is land application of wastewater. The wastewater is usually sprayed over natural or specially sloped and seeded land. The wastewater seeps into the soil where natural solid microorganisms consume the wastes. The treated water is either used by plants, stays in the ground, or is collected and routed to a receiving stream.



# Sludge Handling:

## Concentration is the Name of the Game

As the flow of wastewater moves through a treatment plant, various types of solids are removed to restore its purity. Handling those solids can become more expensive and complex than the continuing purification of the main waste stream. Relatively speaking, removing the solids is easy, compared to the effort that goes into handling them once they are taken out.

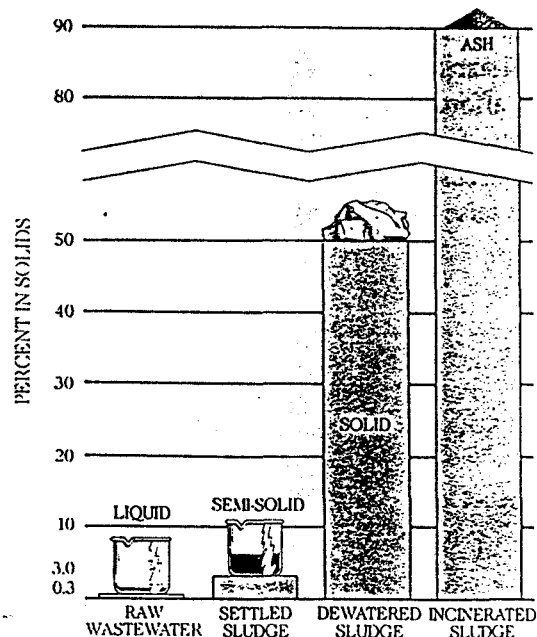
Treatment professionals refer to solids in general as **sludge**. Beneficial sludges are called "biosolids". But these solutions are not the thick, molasses-like substances that most people think of when they hear the word "sludge". Wastewater sludges are slurries of water and solids that are roughly 100 times more concentrated than untreated wastewater. That is, they contain about 3 percent solids compared to the .03 percent (or less) concentration of the initial flow into a treatment plant. The various techniques for handling these flows are designed to increase the solids concentration even further, to as much as 50 percent.

As a rule of thumb, higher degrees of wastewater treatment produce larger volumes of sludge. For example, primary treatment usually produces 2,500 to 3,500 gallons of sludge for every 1 million gallons of wastewater. Secondary treatment usually produces 15,000 to 25,000 gallons for every 1 million gallons treated. To try to dispose of or recycle such volumes of waste is practical. Thus sludge handling methods are designed to remove as much water from the mixture as possible.

The spectrum of sludge handling techniques is divided into processes that condition, thicken, stabilize, and dewater the sludge flow. Conditioning operations usually employ chemicals or heat to make the sludge release water more easily. Thickening techniques use gravity, flotation, and chemicals to separate water from the solids. Conditioning and thickening are usually the first steps in handling primary and secondary sludges.

Stabilization converts the organic matter in the sludge so that the biosolids can be disposed of or used as a soil conditioner without posing a health hazard in the general environment. Sludge stabilization can occur with (aerobic) or without (anaerobic) oxygen in special tanks called digesters. Sometimes chemicals such as lime are used for stabilization.

Dewatering is done by mechanical means. Filters, centrifuges, and presses remove even more water from the biosolids. Biosolids dewatered by such equipment have the consistency of wet mud and can have a solids concentration of up to 20 percent. Other techniques such as drying beds or special presses can be used to dewater the sludge, producing up to 50 percent solids-about the consistency of dry soil. At the end of a sludge handling process, the concentrated solids can be placed in landfills, incinerated, applied to land, or composted for use as a soil conditioner.



In various sludge handling steps, more and more water is removed to increase the solids concentration and make ultimate disposal more economical.

# Plant Management:

## Directing a Case of Many Players

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The successful performance of a wastewater treatment facility, be it large or small, requires the support of a large number of people whose contribution may not be readily apparent when visiting the actual treatment facility.

The wastewater treatment facility staff is responsible for treatment of a waste stream whose characteristics can change daily or even hourly according to factors such as the weather or industrial activities. Either challenge is to convert this widely variable incoming flow (influent) into a consistent outgoing flow (effluent)-treated wastewater that is safe for return to the environment.

In addition to producing clean effluent, proper management of the wastewater treatment facility means an economically efficient operation. Such an operation makes the best use of funds generated through local user charges. In addition to operation and maintenance (O&M) costs, sufficient revenue is needed to meet the annual debt service requirements, or mortgage, on the plant facilities. Wastewater treatment plants are complex facilities, requiring substantial sums of money to construct. Few local governments can afford to pay cash for construction, even if they benefit from federal or state construction grants. It is, therefore, necessary to sell bonds or arrange private financing to raise the required local capital. This money is

paid back over a number of years.

The plant manager may be seen as the "battlefield commander" in the war on water pollution. It is the plant manager's job to bring together money, manpower, and materials in an efficient manner to accomplish these objectives of the treatment plant-collection, treatment, and ultimate disposal of wastewater in a manner that is safe and legally acceptable. The basic management functions required to carry out these objectives are identical from plant to plant, but vary in scope depending on the size, location, complexity, and condition of the facility.

In a small town, the wastewater plant manager may have direct access to the mayor and may supervise only one or two employees. In a large metropolitan area or sewer district, the wastewater plant manager may be part of a large hierarchy that includes a mayor, public works director, special board or commission, or other officials above him, and another hierarchy of foremen, operators, and maintenance men below.

The plant manager has overall responsibility for many essential support functions. Among the most important are community relations, budgeting, training, maintenance, and plant safety.

Being a good neighbor is an important part of the

process. A good community relations program will inform the public about the importance of wastewater treatment and increase public support for water pollution control programs. Community relations can be enhanced through plant open houses, contacts with local news media, and information distributed with customer bills.

Budgets are typically prepared on an annual basis, and include funds for day-to-day operation of the plant as well as maintenance and replacement of equipment. Since local governments cannot operate in the red, user charges must be annually reviewed and adjusted as necessary to keep pace with costs. Plant operation and maintenance typically cost approximately twice as much per year as the annualized capital cost of constructing the treatment facility.

Adequate training of personnel is critical. Generally, on-site training is provided initially by the engineering firm that designed the plant and by equipment manufacturers. Subsequent training becomes the responsibility of the treatment facility staff. In a large facility, a separate training department may be established.

In almost all states, state certification or licensure is required for individuals who operate wastewater treatment facilities. Such licenses can be obtained only after hands-

on experience, formal training, and passage of a comprehensive exam.

Equipment maintenance is critical to the continued successful operation of a wastewater treatment plant. Plants generally do not fail to perform because of poor operation, but, rather, because of lack of proper maintenance. Adequate maintenance personnel and programs ensure the long-term cost-effectiveness of the facility.

Because the collection and treatment of wastewater is a relatively hazardous occupation, safety consciousness is an essential part of every correctly managed plant. A proper safety program includes regular training in safety and emergency procedures and availability of necessary safety apparatus for all plant and collection system personnel.

The plant manager is also responsible for many other activities that are part of any large business or industrial operation. These include purchasing, personnel, recruitment, long and short-term planning, and evaluation.

The problems encountered in water pollution control are many and varied and are often unique. Because of this variety of problems, the plant manager and staff must also be innovators. Hard-earned knowledge must be combined with new information to result in a well-run treatment plant.

# Monitoring and Permits: A Constant Flow of Data

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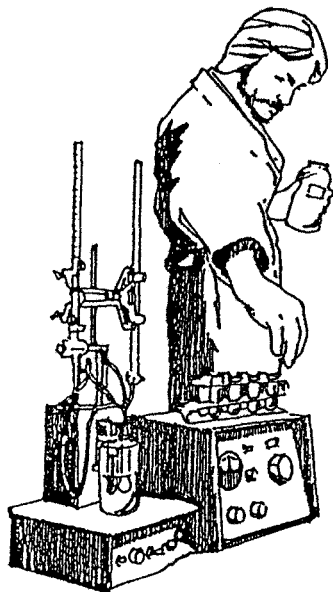
When we want to check a person's general health, we may do nothing more complicated than check temperature and pulse. In a typical treatment plant, there are many sampling points and laboratory tests by which the "health" of the processes are monitored. Sampling and monitoring usually start at the beginning of the treatment plant as the untreated wastewater flows into the plant. Some sampling is done by hand: bottles are lowered into the flow to collect samples for analysis at a laboratory. Some is automatic: ingenious devices measure the various properties of the flow, reporting electronically to a central information bank. Each of the treatment steps we have described in this booklet has its own sampling and monitoring requirements.

Treatment operators must know what is going on at each stage of the general process so they can adjust the controls to compensate for changes in the composition and behavior of the flow and its contents. Many treatment plants have their own laboratories and in large metropolitan treatment operations

these centers are as sophisticated as any used by the medical profession. Mini- and micro-computers are frequently employed to store, retrieve, and evaluate the data obtained in a monitoring program. Some analytical instruments used in a comprehensive monitoring program can detect traces of substances down to one part of pollutant per billion parts of water or even lower.

Many of the monitoring requirements and pollutant discharge limits are specific in a treatment plant's discharge permit. Since 1972, every treatment plant (and every industrial or commercial facility) that discharges directly to a body of water must have such a permit issued by an approved state agency or by the U.S. Environmental Protection Agency (U.S. EPA). Today there are approximately 60,000 permits in force across this country. Of that total, 15,000 are held by municipal treatment plants and 45,000 by industrial plants. The authority for issuing these permits comes from federal law. Many states exercise this authority directly; some allow the U.S. EPA to maintain responsibility. The system under which they are administered is called the National Pollutant Discharge Elimination System, or NPDES for short.

NPDES permits tell the treatment authority how often to sample and report on the quality of its final effluent. Each permit for municipal plants is based on a minimum of primary treatment plus any additional treatment required to meet the water quality standards of the receiving stream. Permits are valid for a specified period of time, but they can be re-opened at any time if national or state requirements change or if the nature of the plant's waste stream changes significantly.



Control of a wastewater treatment plant requires many sophisticated laboratory analyses.

# Infiltration and Inflow: Insidious and Inflationary

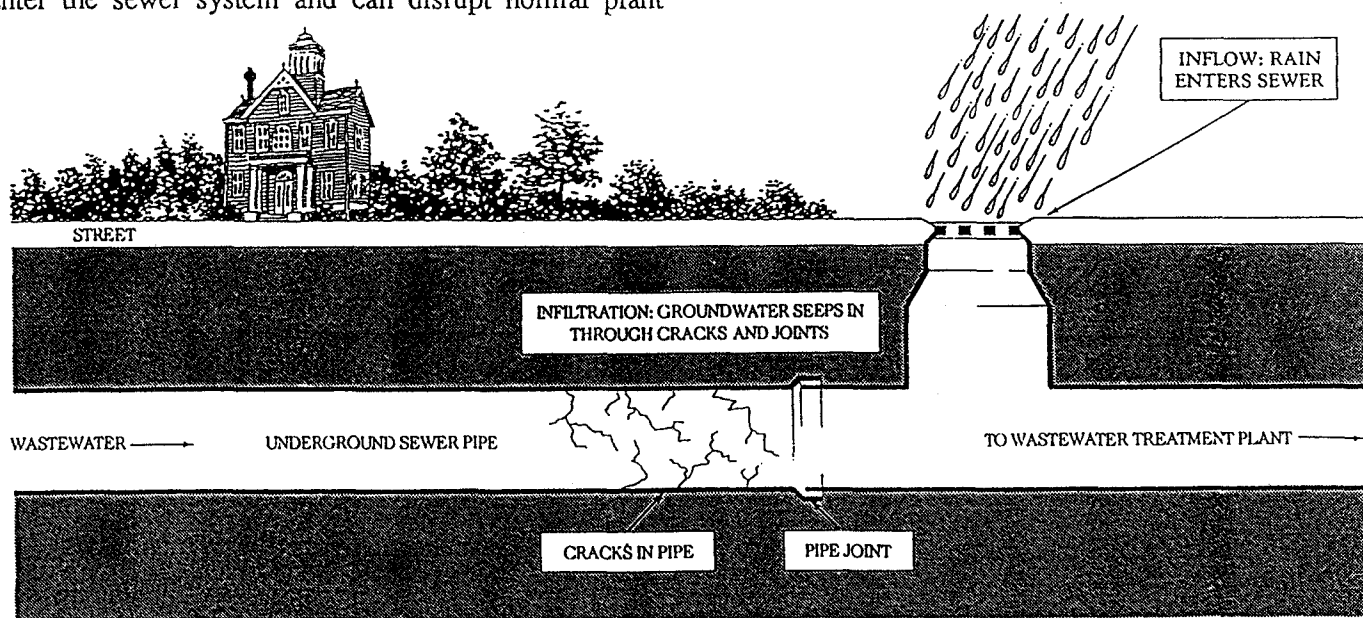
Wastewater is delivered to a treatment plant through a system of municipal sewer pipelines. Such systems stretch for hundreds, even thousands of miles, connecting each domestic and industrial customer to the treatment plant at the end of the network. Pipes settle, manholes crack, brick and mortar crumble. Sewer systems are never completely watertight.

In the ideal world, treating the wastewater that comes to a plant through a sewer system is challenge enough. But in the real world, this challenge is made even greater by the intrusion of ground and surface water. This additional water is called inflow when it enters a sewer above ground or from connections with storm sewers. It is called infiltration when it enters the pipes below ground. The term I/I describes this phenomenon. The amount of inflow that enters a system depends on the number of low-lying manhole covers and cross connections within a storm drainage system. The amount of infiltration depends on the number and size of cracks, holes, and leaky joints in the piping system. When it rains, large volumes of I/I can enter the sewer system and can disrupt normal plant

operations, lowering treatment efficiency.

It is usually impossible to eliminate all sources of I/I. Federal and state authorities generally agree that up to 76 litres of I/I per person per day may be a reasonable amount of additional water to process; more than that, and a community must pay a significant amount to treat water it never pollutes. Studies of some systems have found infiltration can add up to 100 gallons per person per day to normal wastewater flow. Treating the extra water is expensive because more capacity is needed to handle it at the plant. But efforts to correct I/I are sometimes ineffective, and also very expensive.

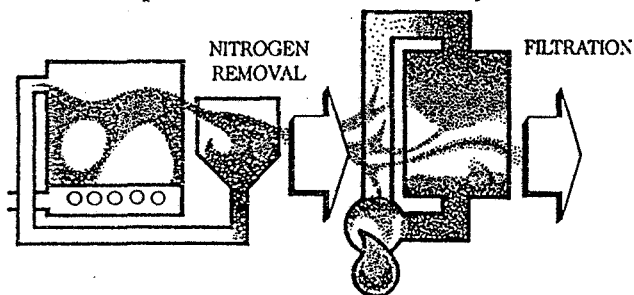
Sometimes 80 percent of the problem can be corrected by repairing 20 percent of the leaks. The trick is to find the right 20 percent. Finding leaks is sometimes harder than fixing them, but fixing them is more expensive. Encouraging advances have been made in I/I detection and some ingenious corrective techniques have been developed recently. Reducing infiltration and inflow saves the treatment authority-and its customers-money.



Common sources of infiltration and inflow.

# Advanced Waste Treatment: Customizing a Plant's Discharge

Every body of water has its own particular characteristics. Each reacts somewhat differently to the discharge of treated wastewater. In most cases, secondary treatment will remove over 85 percent of the biochemical oxygen demand and suspended solids. This is usually sufficient to



Sometimes complex advanced wastewater treatment steps are added to remove specific constituents that remain in the wastewater after primary and secondary treatment.

make the discharge acceptable to the receiving stream. But there are situations where even higher degrees of treatment must be provided. In these instances, the extra processing is known by the general term advanced waste treatment or AWT.

Advanced waste treatment processes represent one frontier of applied science in water pollution control. Decisions to install AWT processes are not made lightly. Such systems are usually expensive to build and to operate; they normally demand a highly trained operating crew. Sometimes they produce sludges that are difficult to dispose of economically. These techniques can be used, if necessary, to tackle the toughest kinds of wastewater problems. They can produce treated water pure enough to use in industrial processes, to irrigate golf courses and park land, or to replenish groundwater.

Different types of AWT processes are used to remove specific constituents that remain in the wastewater after secondary treatment. In certain cases, AWT systems are designed to remove specific toxic substances that may be present in the waste stream, but generally, the most common types of AWT systems remove nutrients and suspended solids.

## Nutrient Removal

All domestic and some industrial wastewaters contain substances which serve as nutrients. Discharging too

many nutrients can overstimulate the growth of algae and other aquatic vegetation. Excessive plant growth can use so much dissolved oxygen that an insufficient amount remains for fish and other aquatic life.

Thus, some treatment plants must employ AWT processes to remove nutrients. One of the principal nutrients to control is phosphorus. Phosphorus stimulates the growth of algae in surface waters. Typically, phosphorus is removed by adding chemicals to separate it from the wastewater so it can be removed as sludge. Like phosphorus, nitrogen is a nutrient, essential for growth but harmful when discharged in large quantities into lakes or streams. Nitrogen is present in the form of ammonia in domestic wastewater. Primary and secondary treatment usually remove less than half of the ammonia. In the receiving water, ammonia demands additional oxygen and in some cases is toxic to fish. AWT processes can convert ammonia to another compound, nitrate. This conversion is called nitrification and in it, special bacteria change the ammonia to nitrates, a compound that is less harmful to receiving waters.

In some cases a stream is so sensitive to nitrogen that almost all nitrogen must be removed from the wastewater to maintain acceptable water quality. An additional biological process, known as denitrification, is employed. Denitrification converts the nitrogen in nitrates to nitrogen gas, a harmless gas which is then released into the atmosphere.

## Filtration

Sometimes it is necessary to achieve a higher level of suspended solids removal than is possible through primary and secondary screening and sedimentation. This is often accomplished by filtration. In this process, wastewater passes through granular materials such as sand and coal. Usually, several types and sizes of filtering materials are mixed together in what is known as a multimedia filter. Eventually, the filter becomes clogged with materials removed from the wastewater. The filter is then cleaned by reversing the wastewater flow in a process known as backwashing.

# Biosolids Management:

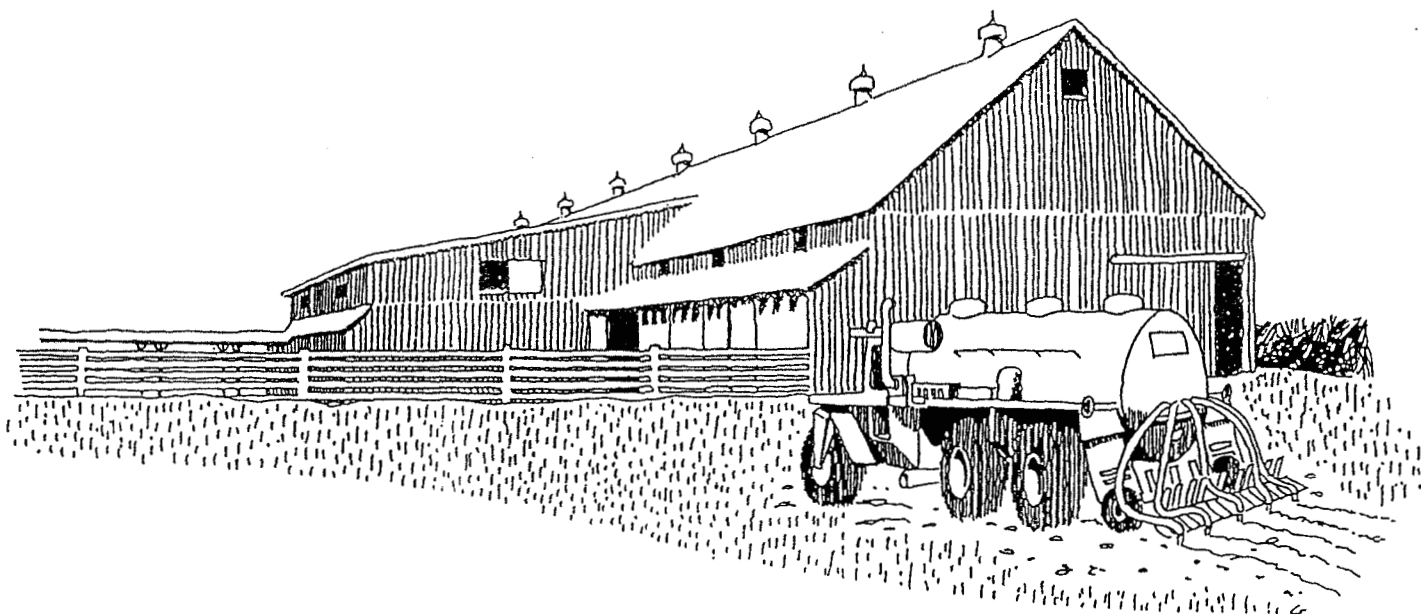
## The Challenge is More Than Technical

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Long-term disposal or reuse of wastewater treatment sludges remains a difficult goal to achieve. The Law of Conservation dictates that matter can never be created or destroyed. It can only be changed from one form into another. A popularization of that law puts this point even more simply: *Everything must go somewhere*. That is the problem facing many treatment authorities today. Nobody wants to live next to the "somewhere" for municipal biosolids. Plans to burn it or distribute it on land abound, but public acceptance is the critical factor in most cases. In the final analysis, an effective, economical biosolids management program depends on community awareness of the fact that it can have beneficial uses and can be safely disposed of without environmental damage.

One of the foremost beneficial uses of biosolids is **land application**. In this alternative, the organic matter is recycled into the soil. It adds bulk to thin soil, improves water retention, changes acidity, and stops erosion, making biosolids ideal for land reclamation projects. Other solids with enough nutrients in them can be used to improve the yields of agricultural lands. Still other schemes involve mixing solids with wood chips, leaves, or shredded paper in a composting operation that creates a product that can be used on lawns, parks, and golf courses.

The most common and oldest method of biosolids disposal is burial in a landfill. Many municipalities have elected to install incinerators as a means to make disposal easier by changing the solids into ash. The ash can be disposed of in a landfill.



Sludge can have beneficial uses in improving agricultural soil.

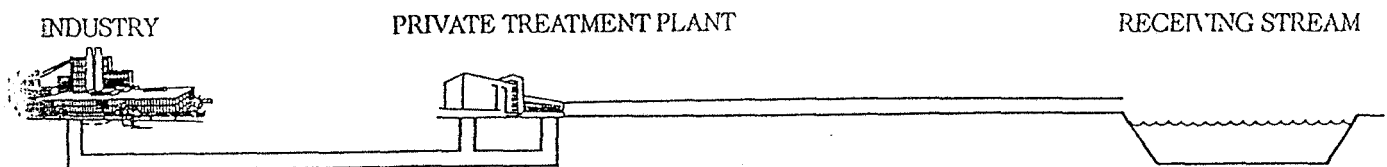
# Industrial Wastes:

## Compatibility is the Key to Effective Treatment

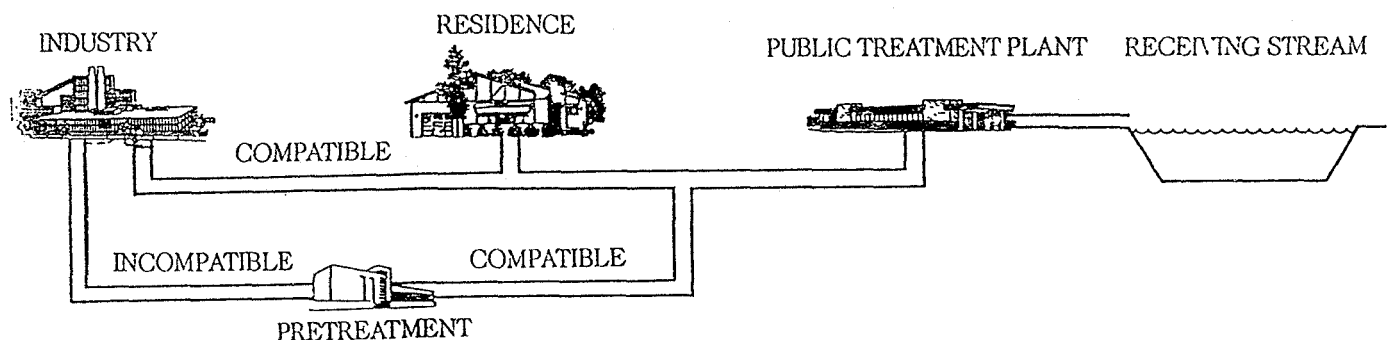
Many industries treat their own wastewater before discharging it to a stream, river, lake, or estuary. In these cases NPDES permits limit what may be discharged. There are approximately 45,000 industrial permit holders. Many other industries rely on publicly owned treatment works (POTW).

Virtually every POTW treats industrial wastewater along with its domestic flows. The term "industrial wastewater" covers discharges from small businesses such as service stations, laundromats, dry cleaners, and restaurants as well as from large installations such as refineries, mills, and food processing plants.

The pollutants in industrial wastewater fall into two groups: those that are basically compatible with municipal treatment and those that are not. A municipal treatment authority charges its industrial customers to treat compatible wastes. For high concentrations of such wastes, a surcharge is usually added. Incompatible substances cannot be discharged to a publicly owned system. Local governments have developed sewer use ordinances that specify which substances are prohibited. Industrial customers can pretreat their wastewater. Pretreatment removes prohibited substances from wastewater before discharge to a municipal sewer system.



Many industries treat their own wastes in private treatment plants.



Other industries send wastes to publicly owned treatment plants.

# Glossary

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**Activated Sludge** - is the sludge that results when primary effluent is mixed with bacteria-laden sludge and then agitated and aerated to promote biological treatment.

**Advanced Waste Treatment** - wastewater treatment beyond the secondary or biological stage that includes the removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids.

**Aerobic** - life or processes that require, or are not destroyed by, the presence of free elemental oxygen.

**Anaerobic** - life or process that require, or are not destroyed by, the absence of free elemental oxygen.

**Bacteria** - unicellular microscopic organisms that perform a variety of biological treatment processes, including biological oxidation, sludge digestion, nitrification, and denitrification.

**Biochemical Oxygen Demand (BOD)** - a measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution.

**Biosolids** - the primarily organic solid product, produced by wastewater treatment processes, that can be beneficially recycled.

**Combined Sewer** - a sewer system that carries both sanitary sewage and stormwater runoff.

**Denitrification** - the reduction of nitrate nitrogen to nitrogen gas.

**Effluent** - wastewater, treated or untreated, that flows out of a treatment plant, sewer, or industrial outfall.

**Infiltration** -- entry of water into a sewer system through such sources as defective pipes, pipe joints, connections, or manhole walls.

**Inflow** - entry of water into a sewer system from sources other than infiltration, such as basement drains, storm drains, and street washing.

**Influent** - water, wastewater or other liquid flowing into a reservoir, basin, treatment plant, or treatment process.

**Land Application** - the treatment or disposal of wastewater or wastewater solids by spreading it on land under controlled conditions.

**Microorganisms** - microscopic organisms, either plant or animal, invisible or barely visible to the naked eye. Examples are algae, bacteria, fungi, protozoa, and viruses.

**National Pollution Discharge Elimination System (NPDES)** - the permit process established under section 402 of the Clean Water Act to define the allowable quantity and quality of discharges to receiving streams.

**Nitrification** - the oxidation of ammonia nitrogen to nitrate nitrogen in wastewater by biological or chemical reactions.

**Nutrients** - any substance that is assimilated by organisms and promotes growth; generally applied to nitrogen and phosphorus in wastewater, but also applied to other essential and trace elements.

**Nitrification** - the oxidation of ammonia nitrogen to nitrate nitrogen in wastewater by biological or chemical reactions.

**Operations and Maintenance (O&M)** - the organized procedure for causing a piece of equipment or a treatment plant to perform its intended functions and for keeping the equipment or plant in such a condition that it is able to continually and reliably perform its intended function.

**POTW** - Publicly owned treatment works. The term used in the Clean Water Act to refer to municipal wastewater treatment facilities which may be constructed with the help of federal grants.

**Permit** - a legal document issued by a government agency. In wastewater treatment, a discharge permit requires that the plant operator achieve specific water quality standards and discharge limits by a certain date, and also establishes monitoring and reporting requirements.

**Pretreatment** - the treatment of industrial wastewater at its source before discharge to municipal collection systems.

**Primary Treatment** - the first stage in wastewater treatment. Screens and sedimentation tanks are used to remove most material that floats or will settle. Primary treatment results in the removal of a substantial amount of suspended matter but little or no dissolved or colloidal matter.

**Receiving Stream** - a river, lake, ocean, or other watercourse into which wastewater or treated effluent is discharged.

**Sanitary Sewer** - a sewerage system that carries only household and commercial wastewater.

**Secondary Treatment** - generally, a level of treatment that produces removal efficiencies of 85 percent for BOD and suspended solids. Sometimes used interchangeably with the concept of biological wastewater treatment, where wastewater is mixed with air or oxygen and sludge to encourage the growth of bacteria that "eat" organic pollutants.

**Sludge** - the accumulated solids separated from liquids, such as wastewater.

**Suspended Solids (SS)** - solid pollutants that either float on the surface of, or are suspended in, wastewater.

**Trickling Filter** - a filter of natural or synthetic material used to support bacterial growth and provide secondary treatment of wastewater.

**User Charges** - charges made to users of water and wastewater systems for services supplied.

**Wastewater** - the spent or used water from a community or industry that contains dissolved or suspended matter.

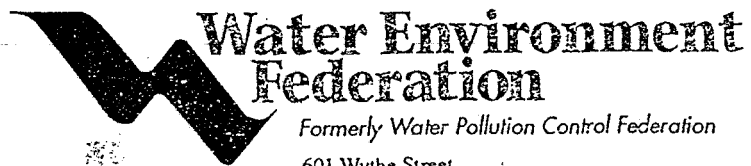
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## Epilogue

Effective wastewater treatment depends on the participation and support of all sectors of the American public - from Congress to the individual citizen. People are the key to adequate funds for construction, operation, and maintenance of necessary treatment facilities. Competent personnel are needed to operate the sophisticated processes

described in this booklet. And state and federal legislators must ensure water quality goals are attainable through workable, cost-effective regulations. With a clear understanding of the value and needs of adequate wastewater treatment, people can work together to ensure that our national clean water goal is attained.

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